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SOUTH AFRICAN STANDARD

Standard Specification for

Intrinsically safe electrical apparatus

SABS 549-1987

Second Revision
Published by
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SOUTH AFRICAN BUREAU OF STANDARDS

STANDARD SPECIFICATION

for

INTRINSICALLY SAFE ELECTRICAL APPARATUS

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NOTICE

This specification was approved by the Council of the South African Bureau of Standards on 3 June 1987.

Intrinsic SAFETY — SABS — Intrinsieke VEILIGHEID

Manufacturers producing intrinsically safe electrical apparatus to this specification may, under a permit issued by the Council of the South African Bureau of Standards, apply the standardization mark as illustrated above to the commodity as evidence to the purchaser that the commodity is being made in accordance with the specification and that compliance with its requirements is ensured by tests and inspections carried out by the South African Bureau of Standards.

NOTE
a) In terms of the Standards Act, 1982 (Act 30 of 1982) it is a punishable offence for any person other than a permit holder to apply a standardization mark to a commodity or to refer to the South African Bureau of Standards or any of its specifications in a manner likely to create the impression that the commodity has been approved by the South African Bureau of Standards or complies with the specification requirements.
b) Authorities who wish to incorporate, in terms of section 33 of the Act, this specification into any law, should consult the South African Bureau of Standards regarding the implications concerned.

This specification will be revised when necessary in order to keep abreast of progress. Comment will be welcomed and will be considered when the specification is revised.

Second Revision June 1987
This specification supersedes SABS 549-1977

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SOUTH AFRICAN BUREAU OF STANDARDS

STANDARD SPECIFICATION

for

INTRINSICALLY SAFE ELECTRICAL APPARATUS

1. SCOPE

1.1 This specification covers constructional and electrical requirements for intrinsically safe electrical apparatuses, circuits and their components.

NOTE
a) Where part of the equipment that is to be assessed for intrinsic safety is to be mounted outside a hazardous area or protected by other means, for example in a flameproof enclosure, the assessment of intrinsic safety may be restricted to cover only such electric sparking or thermal effects as may occur within the hazardous area or outside the flameproof enclosure. Any certificate of intrinsic safety will then define the circumstances to which it applies.
b) The standards referred to in the specification are listed in Appendix A.
c) Notes on the design of intrinsically safe circuits with limiting values of circuit parameters are given in Appendix B.
d) Information regarding the verification of the quality of intrinsically safe apparatus produced to this specification and the sampling plan to be used to assess compliance with the specification of a lot of intrinsically safe electrical apparatus are given in Appendix C.

2. DEFINITIONS

2.1 For the purposes of this specification the definitions given in IEC Publication 112 and the following definitions shall apply:

Acceptable. In relation to the standardization mark and to consignment inspections carried out by the Bureau, acceptable to the South African Bureau of Standards.
Approved. Approved by the Approving Authority.
Approving Authority. The appropriate of the following:
a) Within the scope of the Machinery and Occupational Safety Act, 1983 (Act 6 of 1983): the Chief Inspector of Factories;
b) within the scope of the Mines and Works Act, 1956 (Act 27 of 1956): the Government Mining Engineer;
c) within the scope of the activities of the South African Transport Services: the Administration of the South African Transport Services; and
d) within the scope of the Explosives Act, 1956 (Act 26 of 1956): The Chief Inspector of Explosives.

Associated safe location apparatus. Apparatus in which not all the circuits are intrinsically safe, and that affects the safety of the intrinsically safe system of which it forms a part.

NOTE

a) Such apparatus may not be installed in a hazardous location unless provided with appropriate protection, e.g. a flameproof enclosure or Type 'e' protection (see SABS 1031).

b) Examples of associated safe location apparatus are a power unit, fed from a mains supply, supplying power to intrinsically safe apparatus in a hazardous location, or a recorder in a safe location that is actuated by a transducer in a hazardous location.

Fault (in an intrinsically safe circuit or apparatus). A defect in, or breakdown of,

a) any one component or the wiring to it, or

b) the interconnection between components.

NOTE: A defect in, or breakdown of, other components resulting from a fault constitutes, together with that fault, one fault.

Infallible. Descriptive of a component or an assembly that is not liable to become defective in such a manner as to lower the intrinsic safety of the apparatus or system of which it forms part.

NOTE: An infallible component or assembly that complies with the relevant requirements of the specification is considered fault-free when tests of intrinsic safety are made.

Intrinsically safe circuit. A circuit in which any spark, arc, or thermal effect, whether produced normally (i.e. by breaking or closing of the circuit) or accidentally (e.g. by a short-circuit or an earth fault), is incapable, under prescribed test conditions, of causing ignition of a prescribed gas or vapour.

Intrinsically safe electrical apparatus. An apparatus that is suitable for use in a hazardous location and in which all the circuits are intrinsically safe, or an apparatus that is designed to form part of an intrinsically safe system.

Intrinsically safe system. A system comprising apparatus and interconnecting wiring in which any spark or thermal effect in any part of the system intended for use in a hazardous location is incapable, under prescribed test conditions, of causing ignition of a prescribed gas or vapour.

Maximum surface temperature. The highest temperature attained, in normal operation or under the recognized fault conditions (see 3.1.2), by any part of any surface or wiring of an apparatus to which a hazardous atmosphere will have access.

Normal operation. Operation of an intrinsically safe apparatus or system in accordance with its electrical and mechanical design.

Safety factor. A factor by which the value of the maximum working current or voltage of the circuit is multiplied to arrive at the safe limiting value.

Self-revealing fault. A fault that requires corrective measures before the apparatus can be used, and that is immediately obvious to the user.

Testing Authority. A testing laboratory equipped to carry out the tests specified in the specification and whose test certificates are acceptable to the Approving Authority.

3. REQUIREMENTS

3.1 GROUPS, CATEGORIES AND TEMPERATURE CLASSES OF INTRINSICALLY SAFE ELECTRICAL APPARATUS

3.1.1 Groups

a) Intrinsically safe electrical apparatuses shall be of one of the following main groups:

Group 1. Apparatuses intended for use underground in mines in the presence of methane (fire-damp).
Group 2. Apparatuses intended for use above ground.

b) Group 2 apparatuses shall be of one of the Groups 2A, 2B or 2C, as shown in Column 11 of Table 1, according to their suitability for use in atmospheres containing specific gases and vapours.

NOTE: Generally, apparatuses of Groups 2A, 2B and 2C are suitable for use in atmospheres containing propane, ethylene and hydrogen, respectively, these gases being typical of the groups.

3.1.2 Categories of Intrinsically Safe Apparatus

NOTE: Sparking or thermal effects to be taken into account when intrinsically safe circuits are assessed include all those that might arise in practice, either normally or accidentally, both in apparatus in correct operational order, with all components as specified, and in apparatus in which one or more faults have occurred. In addition to the prescribed faults, defects in external wiring will be considered, unless such external wiring is manufactured and installed to the same standards as power wiring. Sparking or thermal effects do not include ignition by the exposure of the glowing filament of an electric bulb or ignition by other means, for example frictional sparking. Such risks must be covered by other means of protection.

3.1.2.1 Category ia apparatus

a) When tested in accordance with 5.7, Category ia apparatus shall be incapable of causing ignition under the following conditions using the following safety factors:

Condition		Safety factor
In normal operation	:	1,5
With one fault	:	1,5
With two faults	:	1,0

b) Category ia apparatus shall be suitable for use in a Class I Division 0 location (see SABS 0108) and shall have no sparking contacts to which a flammable atmosphere has access.

TABLE 1 - PROPERTIES OF SOME FLAMMABLE GASES, VAPOURS AND LIQUIDS RELATED TO APPARATUS SUBGROUPS AND TEMPERATURE CLASSIFICATION

1	2	3	4	5	6	7	8	9	10	11	12
Compound	Melting point, °C	Boiling point, °C	Vapour density compared with air (air = 1)	Flash-point, °C	Flammability limits in air, %(V/V)		Flammability limits in air, g/m³		Ignition tempera-ture, °C	Apparatus group	Apparatus tempera-ture class
					Lower	Upper	Lower	Upper			
Acetaldehyde	-123	20	1,52	-38	4	57	73	1 040	140	2A	T4
Acetic acid	17	118	2,07	40	5,4	16	100	430	485	2A	T1
Acetone	- 95	56	2,0	-19	2,15	13	60	310	535	2A	T1
Acetylacetone	- 23	≈140	3,5	34	1,7	-	-	-	340	2A	T2
Acetyl chloride	-112	51	2,7	4	5,0	-	-	-	390	2A	T2
Acetylene	- 81	- 84	0,9	-	1,5	100	-	-	305	2C	T2
Acrylonitrile	- 82	77	1,83	- 5	3	17	65	380	480	2B	T1
Allyl chloride	-136	45	2,64	<-20	3,2	11,2	105	360	485	2A	T1
Allylene	-103	- 23	1,38	-	1,7	-	28	-	-	2B	-
Ammonia	- 78	- 33	0,59	-	15	28	105	200	630	2A	T1
Amphetamine	-	200	4,67	<100	-	-	-	-	-	2A	-
Amyl acetate	- 78	147	4,48	25	1,0	7,1	60	550	375	2A	T2
Amyl methyl ketone	- 35	151	3,94	(49)	-	-	-	-	-	2A	-
Aniline	- 6	184	3,22	75	1,2	8,3	-	-	617	2A	T1
Benzene	- 6	80	2,7	-11	1,2	8	39	270	560	2A	T1
Benzaldehyde	- 26	179	3,66	65	1,4	-	60	-	190	2A	T4
Benzyl chloride	- 39	179	4,36	60	1,2	-	55	-	585	2A	T1
Bromobutane	-112	102	4,72	< 21	2,5	-	230	-	265	2A	T3
Bromoethane	119	38	3,76	<-20	6,7	11,3	300	510	510	2A	T1
Butadiene	-109	- 4	1,87	<-20	2,1	12,5	25	290	430	2B	T2
Butane	-138	- 1	2,05	-60	1,5	8,5	37	210	365	2A	T2
Butanol	- 89	118	2,55	29	1,7	9,0	43	350	340	2A	T2
Butene	-185	- 6	1,94	-	1,6	10	35	235	440	2B	T2
Butyl acetate	- 77	127	4,01	22	1,4	8,0	58	360	370	2A	T2
Butylamine	-104	63	2,52	- 9	-	-	-	-	(312)	2A	T2
Butyldigol	- 68	231	5,59	78	-	-	-	-	225	2A	T3
Butyl methyl ketone	- 56	128	3,46	23	1,2	8	50	330	(530)	2A	(T1)
Butyraldehyde	- 97	75	2,48	<- 5	1,4	12,5	42	380	230	2A	T3

/TABLE 1 (continued) ....

TABLE 1 (continued)

1	2	3	4	5	6	7	8	9	10	11	12
Compound	Melting point, °C	Boiling point, °C	Vapour density compared with air (air = 1)	Flash-point, °C	Flammability limits in air, %(V/V)		Flammability limits in air, g/m^3		Ignition tempera-ture, °C	Apparatus group	Apparatus tempera-ture class
					Lower	Upper	Lower	Upper			
Carbon disulphide	-112	46	2,64	<-20	1,0	60	30	1 900	100	2C	T5
Carbon monoxide	-205	-191	0,97	-	12,5	74,2	145	870	605	2B	T1
Chlordimethyl ether	-	-	-	-	-	-	-	-	-	2A	-
Chlorobenzene	45	132	3,88	28	1,3	7,1	60	520	637	2A	T1
Chlorobutane	-123	78	3,2	< 0	1,8	10,1	65	390	(460)	2A	(T1)
Chloroethane	-136	12	2,22	-	3,6	15,4	95	400	510	2A	T1
Chloroethanol	- 70	129	2,78	55	5	16	160	540	425	2A	T2
Chloroethylene	-154	- 14	2,15	-	3,8	29,3	95	770	470	2A	T1
Chloromethane	- 98	- 24	1,78	-	10,7	13,4	150	400	625	2A	T1
Chloropropane	-123	47	2,7	<-20	2,6	11,1	70	300	520	2A	T1
Coal tar naphtha	-	-	-	-	-	-	-	-	272	2A	T3
Coke oven gas	-	-	-	-	-	-	-	-	-	*	-
Cresol	11	191	3,73	81	1,1	-	45	-	555	2A	T1
Cyclobutane	- 91	13	1,93	-	1,8	-	42	-	-	2A	-
Cyclohexane	7	81	2,9	-18	1,2	7,8	40	290	259	2A	T3
Cyclohexanol	24	161	3,45	68	1,2	-	-	-	300	2A	T2
Cyclohexanone	- 31	156	3,38	43	1,4	9,4	53	380	419	2A	T2
Cyclohexene	-104	83	2,83	<-20	1,2	-	-	-	(310)	2A	(T2)
Cyclohexylamine	- 18	134	3,42	32	-	-	-	-	290	2A	T3
Cyclopropane	-127	- 33	1,45	-	2,4	10,4	40	185	495	2B	T1
Decahydronaphthalene	- 43	196	4,76	54	0,7	4,9	40	280	260	2A	T3
Diacetone alcohol	- 47	166	4,0	58	1,8	6,9	-	-	640	2A	T1
Diaminoethane	8	116	2,07	34	-	-	-	-	385	2A	T2
Diamyl ether	- 69	170	5,45	(57)	-	-	-	-	170	2A	T4
Dibutyl ether	- 95	141	4,48	25	1,5	7,6	48	460	185	2B	T4
Dichlorobenzene	- 18	179	5,07	66	2,2	9,2	130	750	(640)	2A	(T1)
Dichloroethane	- 98	57	3,42	-10	5,6	16	225	660	440	2A	T2
Dichloroethylene	-122	32	3,55	-10	9,7	12,8	220	650	(440)	2A	(T2)
Dichloropropane	<- 80	96	3,9	15	3,4	14,5	160	690	555	2A	T1
Diethylamine	- 50	56	2,53	<-20	1,7	10,1	50	305	(310)	2A	(T2)

*Apparatus group will depend on the relative proportions of the constituent gases.

/TABLE 1 (continued) ....

TABLE 1 (continued)

1	2	3	4	5	6	7	8	9	10	11	12
Compound	Melting point, °C	Boiling point, °C	Vapour density compared with air (air = 1)	Flash-point, °C	Flammability limits in air, %(*V*/*V*)		g/m^3		Ignition tempera-ture, °C	Apparatus group	Apparatus tempera-ture class
					Lower	Upper	Lower	Upper			
Diethylaminoethanol	-	161	4,04	(60)	-	-	-	-	-	2A	-
Diethyl ether	-116	34,5	2,55	<-20	1,7	36	50	1 100	170	2B	T4
Diethyl oxalate	- 41	180	5,04	76	-	-	-	-	-	2A	-
Diethyl sulphate	- 25	208	5,31	104	-	-	-	-	-	2A	-
Dihexyl ether	- 43	227	6,43	75	-	-	-	-	185	2A	T4
Di-isobutylene	-106	105	3,87	(2)	-	-	-	-	(305)	2A	(T2)
Dimethylamine	- 92	7	1,55	-	2,8	14,4	52	270	(400)	2A	(T2)
Dimethylaniline	2	194	4,17	63	1,2	7	60	350	370	2A	T2
Dimethyl ether	-141	- 25	1,59	-	3,7	27,0	38	520	-	2B	-
Dipropyl ether	-122	90	3,53	< 21	-	-	-	-	-	2B	-
Dioxane	10	101	3,03	11	1,9	22,5	70	820	379	2B	T2
Dioxolane	- 26	74	2,55	(2)	-	-	-	-	-	2B	-
Epoxypropane	-112	34	2,0	<-20	2,8	37	45	580	430	2B	T2
Ethane	-183	- 89	1,04	-	3,0	15,5	37	195	515	2A	T1
Ethanol	-144	78	1,59	12	3,3	19	67	290	425	2A	T2
Ethanolamine	10	172	2,1	85	-	-	-	-	-	2A	-
Ethoxyethanol	-	135	3,1	95	1,8	15,7	-	-	235	2B	T3
Ethyl acetate	- 83	77	3,04	- 4	2,1	11,5	75	420	460	2A	T1
Ethyl acrylate	>- 75	100	3,45	9	1,8	-	74	-	-	2B	-
Ethylbenzene	- 95	136	3,66	15	1,0	6,7	44	-	431	2A	T2
Ethyldigol	-	202	4,62	94	-	-	-	-	-	2A	-
Ethylene	-169	-104	0,97	-	2,7	34	31	390	425	2B	T2
Ethylene oxide	-112	11	1,52	-	3,7	100	55	1 820	440	2B	T2
Ethyl formate	- 80	54	2,55	-20	2,7	16,5	80	500	440	2A	T2
Ethyl mercaptan	-148	35	2,11	<-20	2,8	18	70	460	295	2A	T3
Ethyl methyl ether	-	8	2,07	-	2,0	10,1	49	255	190	2B	T4
Ethyl methyl ketone	- 86	80	2,48	- 1	1,8	11,5	50	350	505	2A	T1
Formaldehyde	-117	- 19	1,03	-	7	73	87	910	424	2B	T2
Formdimethylamide	- 61	153	2,52	58	2,2	16	70	500	440	2A	T2

/TABLE 1 (continued) ....

TABLE 1 (continued)

1	2	3	4	5	6	7	8	9	10	11	12
Compound	Melting point, °C	Boiling point, °C	Vapour density compared with air (air = 1)	Flash-point, °C	Flammability limits in air, %(V/V)		Flammability limits in air, g/m^3		Ignition tempera-ture, °C	Apparatus group	Apparatus tempera-ture class
					Lower	Upper	Lower	Upper			
Hexane	- 95	69	2,79	-21	1,2	7,4	42	265	233	2A	T3
Hexanol	- 45	157	3,5	63	1,2	-	-	-	-	2A	-
Heptane	- 91	98	3,46	- 4	1,1	6,7	46	280	215	2A	T3
Hydrogen	-259	-253	0,07	-	4,0	75,6	3,3	64	560	2C	T1
Hydrogen sulphide	- 86	- 60	1,19	-	4,3	45,5	60	650	270	2B	T3
Isopropylnitrate	-	105	-	20	2	100	-	-	175	2B	T4
Kerosene	-	150-300	-	38	0,7	5	-	-	210	2A	T3
Metaldehyde	246	112	6,07	36	-	-	-	-	-	2A	-
Methane (firedamp)	-182	-161	0,55	-	5	15	-	-	595	1	T1
Methane (industrial)+	-	-	-	-	-	-	-	-	-	2A	T1
Methanol	- 98	65	1,11	11	6,7	36	73	350	455	2A	T1
Methoxyethanol	- 86	124	2,63	39	2,5	14	80	630	285	2B	T3
Methyl acetate	- 99	57	2,56	-10	3,1	16	95	500	475	2A	T1
Methyl acetoacetate	-	170	4,0	67	-	-	-	-	280	2A	T3
Methyl acrylate	<- 75	80	3,0	- 3	2,8	25	100	895	-	2B	-
Methylamine	- 92	- 6	1,07	-	5	20,7	60	270	430	2A	T2
Methylcyclohexane	-127	101	3,38	- 4	1,15	6,7	45	-	260	2A	T3
Methylcyclohexanol	- 38	168	3,93	68	-	-	-	-	295	2A	T3
Methyl formate	-100	32	2,07	<-20	5	23	120	570	450	2A	T1
Naphtha	-	35-60	2,5	- 6	0,9	6	-	-	290	2A	T3
Naphthalene	80	218	4,42	77	0,9	5,9	45	320	528	2A	T1
Nitrobenzene	6	211	4,25	88	1,8	-	90	-	480	2A	T1
Nitroethane	- 90	115	2,58	27	-	-	-	-	410	2B	T2
Nitromethane	- 29	101	2,11	36	-	-	-	-	415	2A	T2
Nitropropane	-108	131	3,06	(49)	-	-	-	-	420	2B	T2
Nonane	- 54	151	4,43	30	0,8	5,6	37	300	205	2A	T3
Nonanol	-	178	4,97	75	0,8	6,1	-	-	-	2A	-

+Industrial methane includes methane mixed with not more than 15 %(V/V) of hydrogen.

/TABLE 1 (continued) ....

TABLE 1 (continued)

1	2	3	4	5	6	7	8	9	10	11	12
Compound	Melting point, °C	Boiling point, °C	Vapour density compared with air (air = 1)	Flash-point, °C	Flammability limits in air, %(V/V)		Flammability limits in air, g/m^3		Ignition tempera-ture, °C	Apparatus group	Apparatus tempera-ture class
					Lower	Upper	Lower	Upper			
Octaldehyde	-	163	4,42	52	-	-	-	-	-	2A	-
Octanol	- 16	195	4,5	81	-	-	-	-	-	2A	-
Paraformaldehyde	-	25	-	70	-	-	-	-	300	2B	T2
Paraldehyde	12	124	4,56	17	1,3	-	70	-	235	2A	T3
Pentane	-130	36	2,48	<-20	1,4	8,0	41	240	285	2A	T3
Pentanol	- 78	138	3,04	34	1,2	10,5	44	380	300	2A	T2
Petroleum	-	-	-	<-20	-	-	-	-	-	2A	-
Phenol	41	182	3,24	75	-	-	-	-	605	2A	T1
Propane	-188	- 42	1,56	-	2,0	9,5	39	180	470	2A	T1
Propanol	-126	97	2,07	15	2,15	13,5	50	340	405	2A	T2
Propylamine	-101	32	2,04	<-20	2,0	10,4	49	260	(320)	2A	(T2)
Propylene	-185	- 48	1,5	-	2,0	11,7	35	210	(455)	2A	(T1)
Propyl methyl ketone	- 78	102	2,97	(16)	1,5	8,2	53	300	505	2A	T1
Pyridine	- 42	115	2,73	17	1,8	12,0	56	350	550	2A	T1
Styrene	- 31	145	3,6	30	1,1	8,0	45	350	490	2A	T1
Tetrahydrofuran	-108	64	2,49	-17	2,0	11,8	46	360	(260)	2B	(T3)
Tetrahydrofurfuryl alcohol	-	178	3,52	70	1,5	9,7	60	410	280	2B	T3
Toluene	- 95	111	3,18	6	1,2	7	46	270	535	2A	T1
Toluidine	- 16	200	3,7	85	-	-	-	-	480	2A	T1
Town gas (coal gas)#	-	-	-	-	-	-	-	-	-	2B	T1
Triethylamine	-115	89	3,5	< 0	1,2	8	50	340	-	2A	-
Trimethylamine	-117	3	2,04	-	2,0	11,6	49	285	(190)	2A	(T4)
Trimethylbenzene	- 45	165	4,15	-	-	-	-	-	470	2A	T1
Trioxane	62	115	3,11	(45)	3,6	29	135	1 100	410	2B	T2
Turpentine	-	149	-	35	0,8	-	-	-	254	2B	T3
Water gas	-	-	-	-	-	-	-	-	-	2C	T1
Xylene	- 25	144	3,66	30	1,0	6,7	44	335	464	2A	T1

#Containing not more than 57 %(V/V) of hydrogen and not more than 16 %(V/V) of carbon monoxide, the remainder being a mixture of paraffin hydrocarbons and inert gas.

3.1.2.2 Group 1 and Category ib apparatus. When tested in accordance with 5.7, Group 1 and Category ib apparatus shall be incapable of causing ignition under the following conditions and using the following safety factors:

Condition		Safety factor
In normal operation	:	1,5
With one fault	:	1,5
With one fault and provided that the apparatus contains no unprotected sparking parts in the hazardous location, and that the fault is self-revealing	:	1,0

NOTE: Category ib apparatus is not suitable for use in a Class 1, Division 0 location. Category ib, Group 2A, temperature Class T3 intrinsically safe apparatus is suitable for use in all Class II and Class III locations (see SABS 0108), where electrically non-conductive materials form the hazard. If Category ib apparatus is intended for use in the presence of electrically conductive dusts (metal and carbon dusts), separate assessment is required.

3.1.2.3 Category ic apparatus. When tested in accordance with 5.7, Category ic apparatus shall be incapable of causing ignition under the following conditions and using the following safety factors:

Condition		Safety factor
In normal operation	:	1,5
With one fault	:	1,5

NOTE
a) A fault that is self-revealing and that can cause not more than one spark (i.e. through the blowing of a fuse or similar circuit arrangements) may, at the discretion of the Testing Authority, be disregarded in the evaluation of intrinsic safety.
b) Category ic apparatus should be limited to surface use or should by virtue of its design and purpose be continuously attended, monitored and observed. Only hand-held apparatuses such as radio transceivers, calculators, meters and the like are deemed to fall into this category.

3.1.3 Surface Temperature Classification

a) The temperature of any surface of an intrinsically safe apparatus to which flammable atmosphere has access shall be limited as follows, based on an ambient temperature of 40 °C:

1) For Group 1 apparatus used in the presence of coal dust, 150 °C;
2) for Group 1 apparatus where coal dust will not be present, 450 °C;
3) for Group 2, the appropriate of the values given in Table 2.

b) When determined in accordance with 5.3, the temperature of any part of a Group 2 apparatus (including its wiring) that is intended to function in a hazardous location shall not exceed the temperature appropriate to the temperature class given in Table 2.

TABLE 2 - CLASSIFICATION OF MAXIMUM SURFACE TEMPERATURES OF GROUP 2 APPARATUS

1	2
Temperature class	Maximum surface temperature, °C
T1	450
T2	300
T3	200
T4	135 (200 for small components of surface area not exceeding 10 cm^2)
T5	100 (150 for small components of surface area not exceeding 10 cm^2)
T6	85

NOTE
1) When the maximum surface temperature of an apparatus is determined, the temperature rise of small components (such as transistors, diodes, resistors) to above the limiting temperature of the class may be ignored provided that the size of the heated area is so limited that the area does not constitute an ignition risk.
2) The maximum surface temperature of an apparatus intended to be used in a hazardous location shall not exceed 80 °C or the maximum appropriate to the temperature class as given in Table 2.
3) For Group 2 electrical apparatus, a maximum surface temperature differing from those given in Table 2 may be selected; the temperature selected shall then be indicated on the apparatus concerned (see 4.1(e)).

3.2 LAY-OUT OF APPARATUS AND WIRING. The lay-out of intrinsically safe electrical apparatus and its wiring shall be such that the transfer of energy (inductive or capacitive) is minimized.

The electrical characteristics and length of external cables shall be as required by the Testing Authority.

3.3 MOUNTING OF COMPONENTS. Each component of an intrinsically safe apparatus shall be so mounted and secured that
a) it is not exposed to damage;
b) its connections will not break or short-circuit in normal conditions of use; and
c) clearances and creepage distances are not reduced by movement of connections or of neighbouring parts.

Component leads (tails) shall be as short as is practicable.

3.4 ENCLOSURES. The construction and materials of an enclosure of intrinsically safe apparatus shall be such that they are acceptable for the service conditions to which the apparatus is likely to be exposed. Light alloy enclosures of Group 1 apparatus shall be in accordance with the recommendations of SABS 012, and light alloy enclosures of Group 2 apparatus shall not contain more than 2 %(*m*/*m*) of magnesium.

3.5 EXTERNAL CONNECTIONS

3.5.1 General. If an intrinsically safe apparatus is such that electrical connections to it must be made by the user, facilities for such connections shall be provided. These shall be screw terminals, plug-socket connectors or other approved types of connectors. All connection devices shall comply with the relevant requirements of 3.5.2 and 3.5.3, and shall be so designed that no damage can occur to leads or components when connections are made.

3.5.2 Screw and Equivalent Terminals (including Soldered Connections)

a) Category ia apparatus. Terminals for Category ia apparatus shall be housed in a separate terminal box, which shall contain no terminals other than those for Category ia apparatus.
b) Group 1 apparatus. The requirements of (a) above shall apply, as far as is practicable, to Group 1 apparatus.
c) Other apparatus. Whether or not terminal boxes are provided on intrinsically safe apparatus or on associated safe location apparatus, terminals for intrinsically safe circuits shall be separated from those for other circuits by a distance of at least 50 mm, or by an earthed metal or insulating barrier of height at least equal to that of the conductive parts of the terminals, and that extends to within 1,5 mm of the adjacent walls of the enclosure or that adds to the clearance between the terminals a distance of at least 50 mm round each end of the barrier. Insulating barriers shall have a thickness of at least 0,9 mm and earthed metal barriers shall have a thickness of at least 0,45 mm .

3.5.3 Plugs and Sockets. Plugs and sockets for intrinsically safe circuits shall be separate from, and non-interchangeable with, plugs and sockets connecting other circuits, except that, in the case of special circuits of Group 1 apparatus (e.g. interlocking or remote-control circuits), intrinsically safe

circuits and other circuits may be powered through the same plug-and-socket assembly.

3.6 INSULATION

3.6.1 When tested in accordance with 5.5, the insulation between an intrinsically safe system or circuit and earth or the frame of an intrinsically safe electrical apparatus shall be capable of withstanding an a.c. test voltage of r.m.s. value 500 V or twice the working voltage, whichever is the greater.

NOTE: The above requirement shall not apply to a circuit or system that is earthed or in which accidental connection to earth at one or more places on the apparatus frame does not result in unsafe conditions.

3.6.2 When tested in accordance with 5.5, the insulation between an intrinsically safe circuit and a non-intrinsically safe circuit of an intrinsically safe electrical apparatus shall be capable of withstanding, without breakdown, an a.c. test voltage of r.m.s. value 1,5 kV or twice the difference between the voltages of the circuits plus 1 kV, whichever is the greater.

3.6.3 Where breakdown between separated intrinsically safe circuits or systems can produce unsafe conditions, the insulation between the circuits shall, when tested in accordance with 5.5, be capable of withstanding an a.c. test voltage of r.m.s. value 500 V or twice the difference between the working voltages, whichever is the greater.

3.6.4 In addition to complying with the requirements given in 3.6.2 or 3.6.3 (as applicable) the insulation between separated circuits shall have a comparative tracking index, as determined in accordance with 5.4, of not less than the value given in Column 4 or 5 (as relevant) of Table 4, appropriate to the difference between the nominal voltages of the circuits that are separated.

3.7 INTERNAL WIRING

3.7.1 Minimum Conductor Sizes. If the wiring of intrinsically safe electrical apparatus of temperature Classes T1-T4 (inclusive) is of copper wire that complies with the requirements of Table 3, the wiring shall be deemed to comply with the requirements for the maximum surface temperature.

3.7.2 Wiring Insulation. Where breakdown between insulated conductors can create an unsafe condition in the circuit or system, wiring of an intrinsically safe circuit shall be insulated with material such that, when tested in accordance with 5.5, the wiring is capable of withstanding, without breakdown, an a.c. test voltage of r.m.s. value 500 V or twice the working voltage of the circuit, whichever is the greater. Non-intrinsically safe circuits in the same enclosure as intrinsically safe circuits shall be wired with cables that comply with the appropriate requirements of SABS 150, or shall be wired with insulated conductors having a grade of insulation such that,

when tested in accordance with 5.5, a cable is capable of withstanding, without breakdown, an a.c. test voltage of r.m.s. value 1,5 kV or twice the difference between the working voltages plus 1 kV, whichever is the greater.

TABLE 3 - CROSS-SECTIONAL AREA/CURRENT RELATIONSHIP FOR COPPER WIRE

1	2
Maximum current, A	Nominal cross-sectional area, mm^2
1,0	0,017
1,7	0,030
3,3	0,090
5,0	0,190
6,6	0,280
8,3	0,400

3.8 CREEPAGE DISTANCES AND CLEARANCES IN INFALLIBLE COMPONENTS

3.8.1 General. Clearances and creepage distances in infallible components shall be not less than the appropriate values given in Table 4.

3.8.2 Infallible Printed-circuit Systems. Distances between conductors of an infallible printed circuit shall conform to the appropriate values given in Column 2 of Table 4, except that, if the printed circuit board is covered with an adherent insulating coating, distances shall conform to the appropriate values given in Column 3.

3.8.3 Infallible Plugs and Sockets for Internal Connections. In infallible plugs and sockets, the clearances and creepage distances between conductors that are not separated by means of an earthed metal barrier shall comply with the requirements of 3.8.1.

3.8.4 Infallible Relays. In the case of an infallible relay that switches currents and voltages of values not exceeding 5 A and 250 V respectively, the product of these values not exceeding 100 VA, clearances and creepage distances shall comply with the requirements of 3.8.1. In all other cases, the conductors of an infallible relay shall be separated by an earthed metal barrier.

3.8.5 Infallible Encapsulated Conductors. Clearances between infallible encapsulated conductors shall conform to the appropriate values given in Column 7 of Table 4.

TABLE 4 - CLEARANCE, CREEPAGE DISTANCE, INSULATION THICKNESSES AND COMPARATIVE TRACKING INDICES

1	2	3	4	5	6	7	8
Peak value of nominal voltage, kV	Creepage distance, mm	Creepage distance undercoating, mm	CTI*		Clearance, mm	Clearance between infallible encapsulated conductors, mm	Thickness of solid insulation, mm
			ia	ib			
0,01	1,5	0,5	90	90	1,5	0,5	0,5
0,03	2	0,7	90	90	2	0,7	0,5
0,06	3	1	90	90	2	1	0,5
0,09	4	1,3	90	90	4	1,3	0,7
0,19	8	2,6	175	175	5	1,7	0,8
0,375	10	3,3	175	175	6	2	1
0,55	15	5	300	175	7	2,4	1,2
0,75	18	6	300	175	8	2,7	1,4
1,00	25	8,3	300	175	10	3,3	1,7
1,30	36	12	300	175	14	4,6	2,3
1,55	40	13,3	300	175	16	5,3	2,7
3,3	67	23	300	175	27	9	4,5
4,7	90	30	300	175	36	12	6
9,5	190	53	300	175	60	20	10
15,6	240	80	300	175	100	33	16,5

*Comparative Tracking Index.

3.9 COMPONENTS

3.9.1 Rating of Components. The design of intrinsically safe electrical apparatus shall be such that a component (other than a transformer) on which intrinsic safety depends, operates at not more than two-thirds of its appropriate rating.

NOTE: Ratings shall be based, at the discretion of the Testing Authority, on those in the relevant SABS standard, IEC Recommendation, British standard, or other standard, or on the values specified by the manufacturer. Manufacturing tolerance shall be taken into account to the extent that if there is maximum loading of the component in the circuit, the Testing Authority has the discretion to assume in the testing that such component has failed before taking into account the component fault(s) specified in 3.1.

3.9.2 Reliability. The standard of reliability and quality of all components on which intrinsic safety depends shall be such that it is acceptable to the Testing Authority.

3.9.3 Plug-in Boards and Components. Plug-in boards and components shall not be interchangeable with non-identical boards or components in the same apparatus.

3.9.4 Cells and Batteries

a) A cell or battery that requires a current-limiting device and that is intended for use in a hazardous location shall be encapsulated with the device or so housed that no conductor or terminal, other than the current-limited terminal(s), is accessible to a flammable atmosphere.
b) The assembly of cell or battery and current-limiting device shall be such that excessive temperature rise of any part of the assembly, or emission of flammable gas, or any abnormal distortion of the cell or battery case does not occur during normal use, or charging, or on continued short-circuit.
c) If cells or batteries are provided with additional terminals (e.g. for charging purposes), provision shall be made to prevent power being taken from these terminals. If these terminals are used for other than their intended purpose, they shall not be capable of supplying a voltage in excess of 1,2 V, a current in excess of 0,1 A, energy in excess of 20 μJ or power in excess of 25 mW . If this is achieved by the use of series diodes, at least one such diode shall be connected to each battery pole.

3.10 INFALLIBLE COMPONENTS

3.10.1 Wiring. Infallible wiring of an intrinsically safe circuit shall be separated from other wiring by one of the following means:

a) By a clearance of at least the appropriate value given in Column 7 of Table 4;
b) by enclosing the wiring of either the intrinsically safe circuit or of the other circuit(s) in an earthed screen;

c) in the case of Category ib apparatus, by providing over the intrinsically safe wiring an additional insulating sleeve that, when tested in accordance with 5.5, will withstand an a.c. test voltage of r.m.s. value at least 2 kV .

3.10.2 Mains Transformers

3.10.2.1 Protective Measures

a) The input circuit of a mains transformer intended for supplying an intrinsically safe circuit shall be protected by a fuse or circuit-breaker. The rated current of a fuse shall be indicated in a position adjacent to the fuse. If the input and output windings are separated by an earthed metal screen (see 3.10.2.2 Type 2(b) construction), each non-earthed input line shall be protected by a fuse or circuit-breaker.

NOTE
1) A fuse or circuit-breaker having a rated current not exceeding three times the rated input current of the transformer is recommended.
2) Additionally, an embedded thermal fuse or other thermal device may be used for protection against overheating of the transformer.

b) When tested in accordance with 5.6, a transformer together with its associated devices (e.g. fuses, circuit-breakers, thermal devices and resistors) shall maintain a safe electrical isolation between the power supply and the intrinsically safe circuit even if one of the output windings is short-circuited and all other output windings are subjected to their maximum electrical loading.

3.10.2.2 Transformer construction

a) All windings for supplying intrinsically safe circuits shall be separated from all other windings by one of the following types of construction:

1) Type 1 construction. By placing them either
i) for Type 1(a) construction, on one leg of a core, side by side in separate bobbins or in separate sections of the same bobbin; or
ii) for Type 1(b) construction, in bobbins on different legs of the core.

2) Type 2 construction. By winding them one over another with
i) for Type 2(a) construction, insulation between the windings;
ii) for Type 2(b) construction, an earthed screen made of copper foil or an equivalent wire winding (wire screen) between the transformer windings.

The thickness of the copper foil or wire screen, as applicable, shall be such that in the event of a short-circuit between any winding and the screen, the screen will be able to withstand, without breakdown, the current that flows before the fuse or circuit-breaker operates (see Table 5).

TABLE 5 - MINIMUM FOIL THICKNESS OR MINIMUM WIRE DIAMETER OF THE EARTHED SCREEN IN RELATION TO THE RATED CURRENT OF THE FUSE

1	2	3	4	5	6	7
Property	Fuse rating, A					
	0,1	0,5	1	2	3	5
Minimum thickness of foil screen, mm	0,05	0,05	0,075	0,15	0,25	0,3
Minimum diameter of wire of wire screen, mm	0,2	0,45	0,63	0,9	1,12	1,4

b) A foil screen shall be provided with two mechanically separated leads to the earth connection, each of which, in the event of a short-circuit between any winding and the screen, is capable of withstanding, without damage, the current that flows before the fuse or circuit-breaker operates.
c) A wire screen shall consist of at least two electrically independent layers of wire, each of which is provided with an earth connection and, in the event of a short-circuit between any winding and the screen, shall be capable of withstanding, without damage, the current that flows before the fuse or circuit-breaker operates.
d) The core of each mains transformer shall be provided with an earth connection, except where earthing is not practicable, as for example, in an insulated toroidal core transformer used in a DC-to-DC converter.
e) The windings of a mains transformer shall have been impregnated in order to consolidate the windings.

3.10.3 Transformers other than Mains Transformers (i.e. transformers such as those used for inverter supply units operating from batteries and coupling transformers such as those used in signal circuits). A transformer other than a mains transformer shall comply with the applicable requirements of 3.10.2.

3.10.4 Damping Windings. An infallible damping winding shall be of reliable mechanical construction. It shall consist of a seamless copper tube or of a winding of uninsulated wire continuously short-circuited by soldering, or shall be of an equivalent construction.

3.10.5 Current-limiting Resistors

a) An infallible current-limiting resistor shall be of the film or metal-oxide type, or it shall be a wire-wound type that incorporates means (e.g. a ceramic covering) to prevent unwinding of the wire in the event of breakage. It shall be rated to withstand the maximum fault current (transient or

continuous) that can arise, shall be mounted close to the terminal being protected, and shall be so positioned that an accidental short-circuit cannot occur.
b) A current-limiting resistor may, if conditions permit, be of a fuse-protected type in which case the fusing time and the rating shall be appropriate to the application.

3.10.6 Blocking Capacitors

a) An infallible blocking capacitor shall be of a high reliability type and shall consist of an assembly of at least two capacitors mounted in series. Electrolytic or tantalum capacitors shall not be used.
b) An infallible blocking capacitor shall be capable of blocking an a.c. voltage of r.m.s. value of $2\,U + 1\,000$ V (where U is the highest voltage which can occur in normal operation between the terminals of the assembly).
c) Where an assembly of capacitors is connected between two separate intrinsically safe circuits or between two parts of the same intrinsically safe circuit, and where the highest voltage which can appear between the terminals of the assembly is less than 90 V, each capacitor shall be capable of withstanding an a.c. voltage of r.m.s. value 500 V .

3.10.7 Shunt-connected Safety Components

a) An infallible shunt-connected safety component shall be so connected, close to a protected component, that it will either not become disconnected or its disconnection will cause simultaneous disconnection of the protected component.
b) A resistor shall be infallible (see 3.10.5).
c) A diode, whether bridge-connected or not, shall have a forward current rating of at least the current that would flow with the protected assembly short-circuited, and shall have a repetitive peak reverse voltage rating of at least 600 V .
d) An infallible safety shunt shall have at least two single components in parallel, disconnection of either of which will not cause the circuit or system to fail the test given in 5.7.

NOTE: Silicon and germanium diodes will be generally suitable for use as safety shunts if the switch-on time (i.e. the time taken for the voltage to fall to within 110 % of the final value when a current stop of 100 mA (rise time 10 ns) is applied) does not exceed 2 μs, and (except where diodes are bridge-connected) the forward voltage drop, at the normal current of the unit and at 25 °C, does not exceed 1 V . Diodes having longer switch-on times or greater forward voltage drops may, however, also be found suitable for some applications.

3.10.8 Infallible d.c. Barriers. An infallible d.c. barrier shall contain at least two infallible blocking capacitors (see 3.10.6) in series, and shall be such that the circuit or system remains intrinsically safe when either of these is short-circuited.

NOTE: The maximum surface temperature in degrees Celsius may be given as an alternative to this.

4.2 MARKING OF DIODE SAFETY BARRIERS. In addition to the marking required in terms of 4.1, the maximum voltage (in volts) which may be safely applied to the non-intrinsically safe connection facilities of a barrier and the maximum open circuit output voltage of the barrier shall appear, in legible and indelible marking, on the barrier. The symbol used for maximum voltage shall be V_M and the symbol used for maximum open circuit output voltage shall be V_z .

Example: $\frac{250\ V_M}{30\ V_z}$ or $250\ V_M$ - $30\ V_z$

4.3 MARKING OF CONNECTION FACILITIES. Connection facilities, terminal boxes and plugs and sockets of intrinsically safe electrical apparatus and associated electrical apparatus shall be legibly and indelibly marked and shall be clearly identifiable. Where a colour is used for this purpose, it shall be light blue.

5. INSPECTION AND METHODS OF TEST

NOTE: The definitions, sampling procedures and criteria of compliance given in Appendix C shall apply.

5.1 GENERAL. If necessary, dismantle the apparatus (partly or completely) for inspection and testing.

5.2 INSPECTION. Visually examine and measure each apparatus for compliance with the requirements of the specification for which tests to assess compliance are not given in 5.3-5.7 (inclusive). Use measuring instruments such as micrometers, voltmeters, etc., where necessary, and measure all relevant circuit parameters such as voltage, current, inductance and capacitance of the circuit under test. Take account of the possible fault conditions referred to in 3.1.2.

5.3 TEMPERATURE RISE TEST OF APPARATUS AND WIRING

5.3.1 Test Conditions. Carry out the test in draught-free air at an ambient temperature of 25 ± 5 °C .

5.3.2 Procedure. Operate the apparatus in its fault-free condition, and also under the relevant fault conditions given in 3.1.2, but not with an overcurrent or overvoltage. Then measure (by any convenient means that has an accuracy of 3 % or better), the temperature of any part of the apparatus or wiring that is intended to function in a hazardous location.

5.4 DETERMINATION OF COMPARATIVE TRACKING INDEX. Use the method given in IEC Publication 112 to determine the comparative tracking index of a test specimen cut from the insulating material.

5.5 VOLTAGE TESTS

5.5.1 Wiring. Use the method given in SABS Method 525.

5.5.2 Other Parts. Apply to the insulation an alternating voltage of substantially sine-wave form at a frequency of between 48 Hz and 62 Hz, supplied from a transformer having an output of at least 500 VA . Increase the voltage steadily to the specified value in a period of at least 10 s and maintain it for at least 60 s .

5.6 TESTS ON TRANSFORMERS

5.6.1 Mains Transformers of Type 1(a), 1(b) and 2(b) Construction

a) Short-circuit the transformer output windings in such a way as to obtain the largest input current, leaving infallible resistors in.
b) Adjust the input current to 1,7 I_n (where I_n is the rated current of the fuse) or to the maximum current at which the circuit-breaker does not trip instantaneously. Do this by adjusting the input voltage. If the input voltage for this exceeds the rated input voltage, do the test at the rated input voltage.
c) Operate the transformer in this condition for at least 6 h, or up to the moment that the thermal trip (if provided) functions.
d) Determine, by the increase in electrical resistance method, whether the temperature rise of any of the transformer windings has exceeded the value permissible for the insulation class of the transformer.

NOTE: Transformers of Type 2(b) construction may exceed this temperature if insulation from earth of the intrinsically safe circuit is not required.

e) Apply a voltage of r.m.s. value 2 500 V or 2 U_n + 1 500 V, whichever is the greater, between any winding used to supply an intrinsically safe circuit and all other windings connected together and determine whether breakdown occurs.

5.6.2 Mains Transformers of Type 2(a) Construction. Carry out the test given in 5.6.1, but subject the input winding to its rated voltage and do not limit the input current.

5.6.3 Transformers other than Mains Transformers. Carry out the test given in 5.6.1(e), but use a test voltage of r.m.s. value 1 500 V or 2 U_n + 1 000 V .

5.7 SPARK TEST

5.7.1 Apparatus, Equipment and Materials

a) Spark test apparatus. Use a spark test apparatus as described in IEC Publication 79-3 but, if this apparatus is not suitable for the circuit under test, use another apparatus by means of which circuit make-or-break sparks can be generated

within an explosive gas mixture, the apparatus being such that it will pass the test given in 5.7.2.

b) Other apparatus and equipment. Use such other apparatus and equipment as are needed to store the gases (see (c) below), to fill and test the spark test apparatus, and to ascertain that, in the spark test, the full current is in fact made and broken.

c) Gas mixture. Use the gas mixture given in Table 6 appropriate to the group or subgroup of apparatus (see also 5.7.4).

TABLE 6 - GAS MIXTURES

1	2
Apparatus group	Gas mixture
1	8,3 ± 0,3 %(*V*/*V*) of methane in air
2A	5,25 ± 0,25 %(*V*/*V*) of propane in air
2B	7,8 ± 0,5 %(*V*/*V*) of ethylene in air
2C	21 ± 2 %(*V*/*V*) of hydrogen in air

5.7.2 Sensitivity of Spark Test Apparatus

a) Ignite the gas mixture as follows:

1) At sea level. In a circuit comprising a 24 V battery, a 95 mH air-cored inductor and current regulating resistors, use an igniting current of the appropriate value given in Column 2 of Table 7. In a circuit comprising a 24 V battery and current regulating resistors having an inductance not exceeding 10 μH, use an igniting current of the appropriate value given in Column 3 of Table 7.

TABLE 7 - MINIMUM IGNITING CURRENTS AT SEA LEVEL

1	2	3
Apparatus group	Inductive circuit, mA	Resistive circuit, mA
1	110	1 500
2A	100	1 000
2B	65	700
2C	30	300

2) At altitudes between 1 400 m and 1 700 m above sea level. In the circuits as specified in (1) above, use the appropriate igniting currents given in Table 8.

TABLE 8 - MINIMUM IGNITING CURRENTS AT ALTITUDES BETWEEN 1 400 m AND 1 700 m ABOVE SEA LEVEL

1	2	3
Apparatus group	Inductive circuit, mA	Resistive circuit, mA
1	110	1 600
2A	100	1 200
2B	65	700
2C	45	450

b) Run the electrode-holder at positive polarity for not more than 400 revolutions. Deem the spark test apparatus to have the required sensitivity if during this period the gas mixture is ignited.

5.7.3 Production of Overcurrents and Overvoltages. Achieve the overcurrent or overvoltage required in terms of 3.1.2 by one of the following means:

a) Inductive circuits (inductance greater than or equal to 1 mH). If practicable, reduce the values of limiting resistance in the circuit. If not, increase the voltage by any convenient means.
b) Resistive circuits (inductance less than 1 mH). Carry out the following steps (in the order given) until the required increase is obtained:

1) If practicable and appropriate, increase the mains supply voltage by 25 %;
2) increase other supply voltages to 10 % above the maximum possible in service, taking into account the manufacturer's tolerances and temperature effects, and other effects;
3) exchange the voltage limiting devices (e.g. shunt diodes or zener diodes) for variants that have a limiting voltage 10 % above the maximum possible in the circuit under test or, if such devices can be adjusted, increase their setting by 10 %;
4) if possible, decrease the values of limiting resistances to obtain the necessary values of test current. When there is more than one current limiting resistor, decrease the values of all such resistors in the same proportion;
5) if steps (3)-(4) above do not produce the required increases, further increase the supply voltage.

c) Capacitive circuits. Increase the voltage.

5.7.4 Substitute for Overcurrent or Overvoltage Effects. If use of an overcurrent or overvoltage is not practicable, the Testing Authority may achieve an equivalent effect by using other methods, e.g. by using in the spark test apparatus a gas that ignites more easily.

5.7.5 Test Procedure. Connect the spark test apparatus in the circuit under test at each point where an interruption, short-circuit or earth fault may occur, and where the circuit characteristics are such that one-third or more of the appropriate current or voltage read from the appropriate curve given in Fig. 1-6 occurs. Determine, from a consideration of the requirements of the specification, points where breaks, short-circuits or earth faults may occur.

Carry out the tests taking into account the possible circuit faults and using the required overcurrent or overvoltages or, when 5.7.4 is applicable, any other appropriate method.

Run the electrode-holder of the spark test apparatus for at least 200 revolutions in the case of a d.c. circuit and for at least 1 000 revolutions in the case of an a.c. circuit.

Observe whether the gas mixture is ignited.

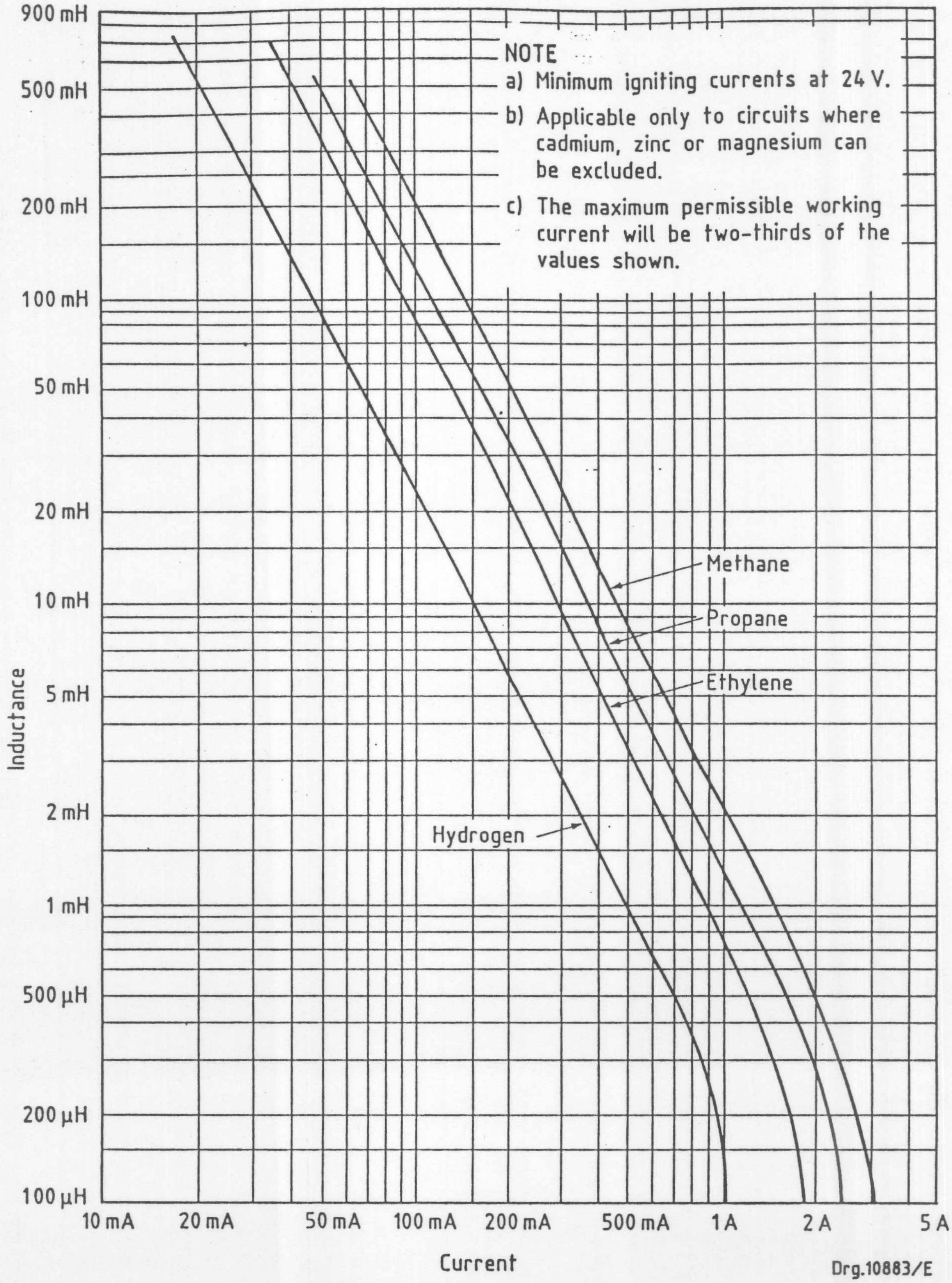

Fig. 1 - Inductive Circuits

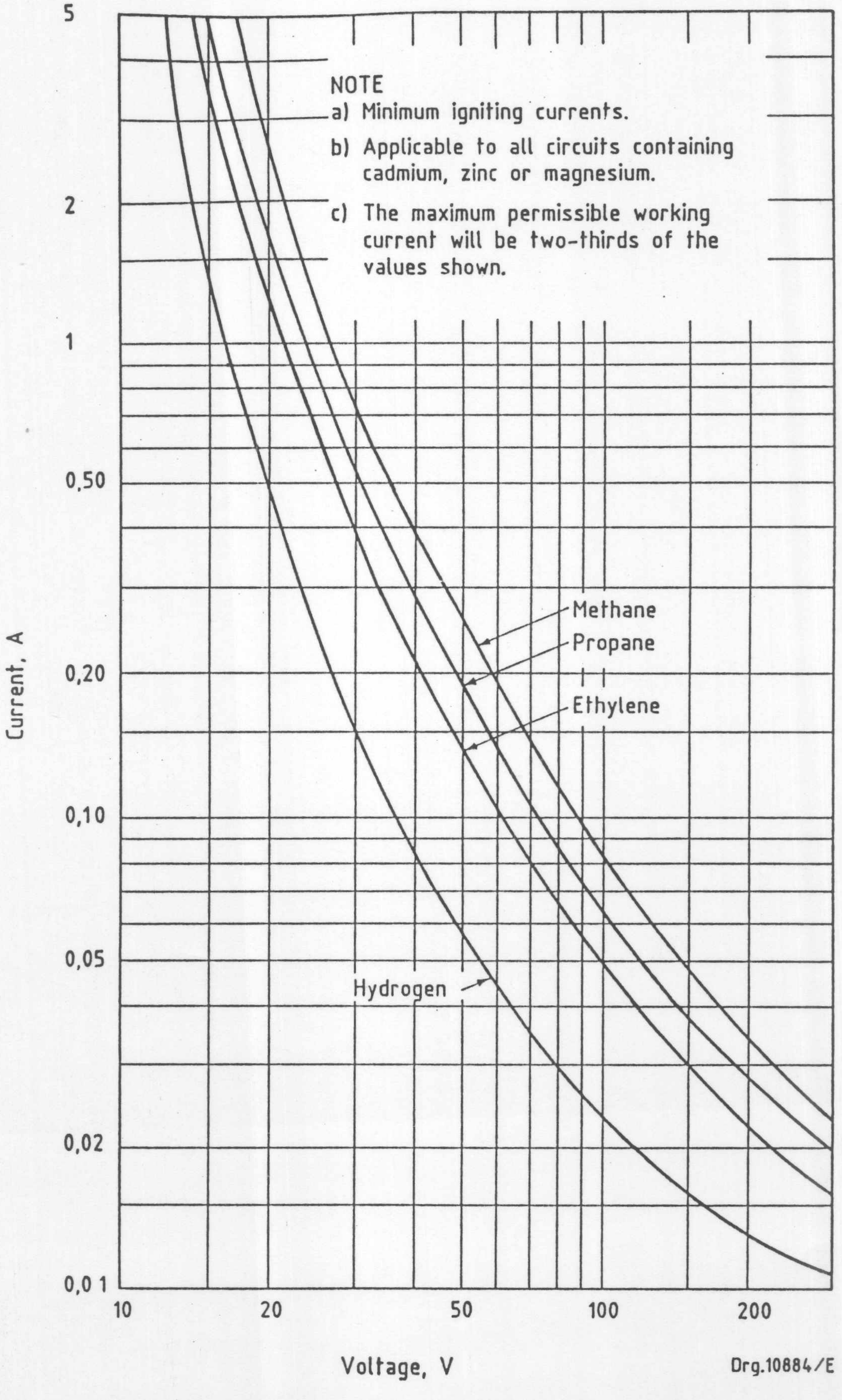

Fig. 2 - Resistive Circuits

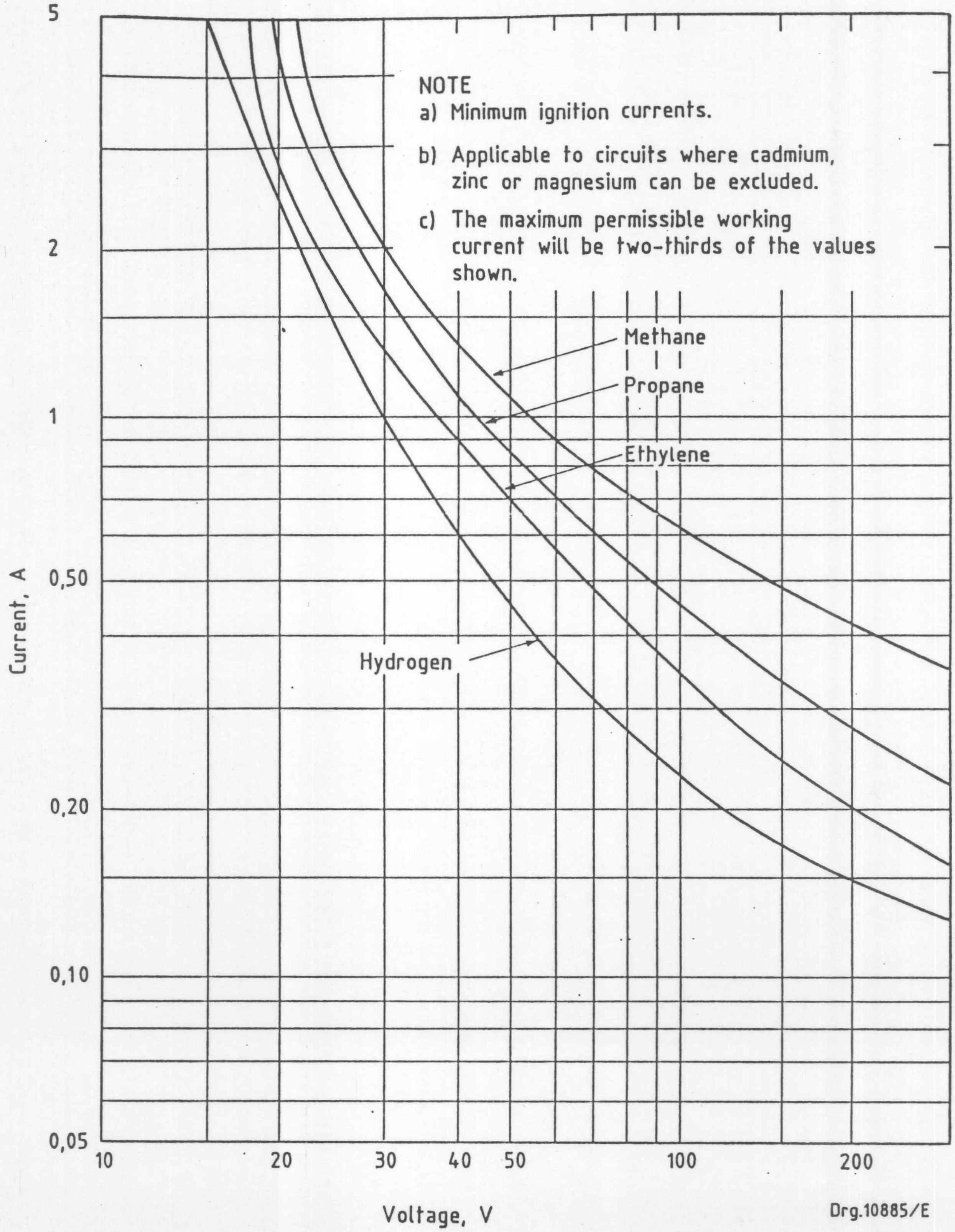

Fig. 3 - Resistive Circuits

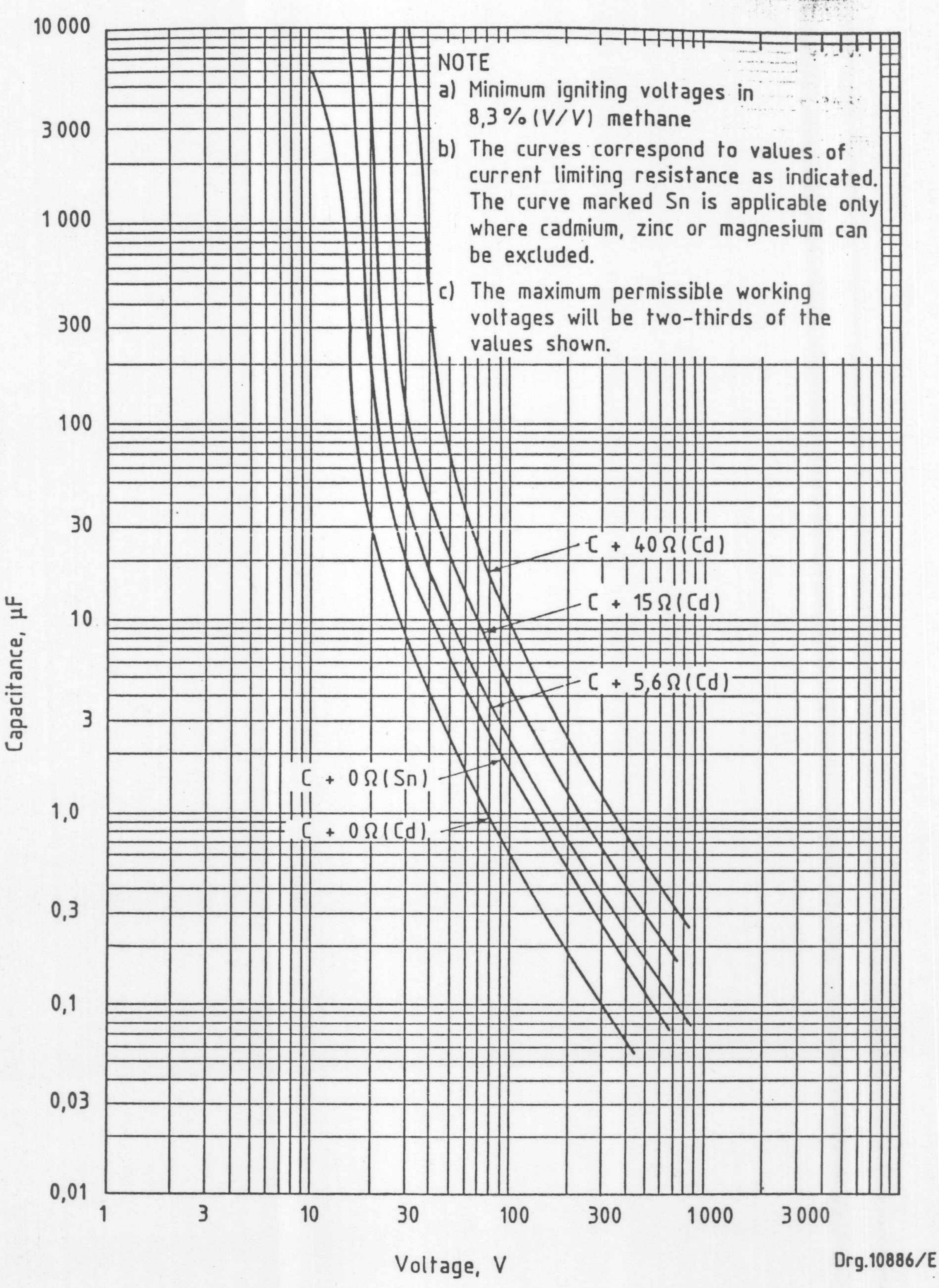

Fig. 4 - Capacitive Circuits

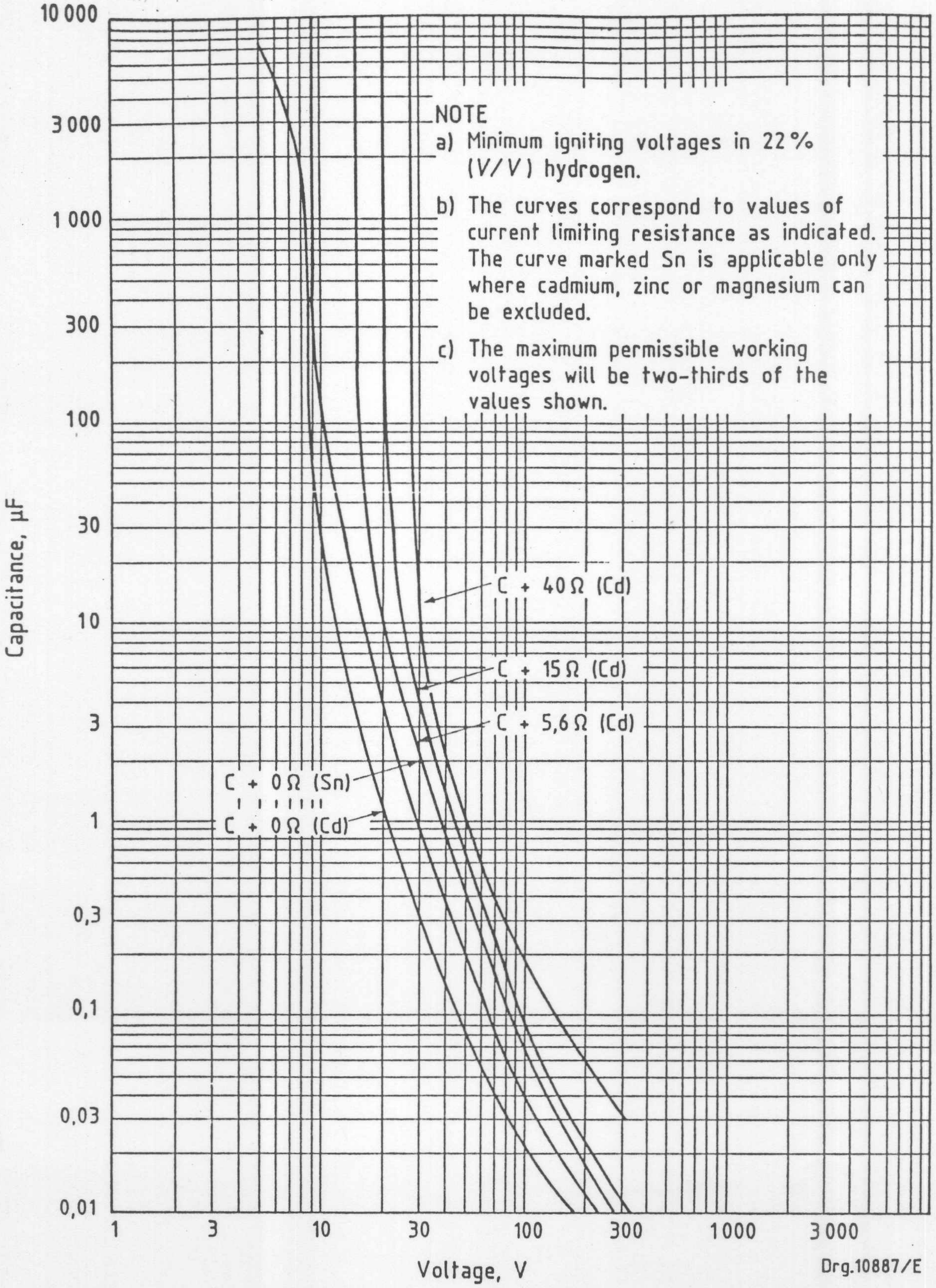

Fig. 5 - Capacitive Circuits

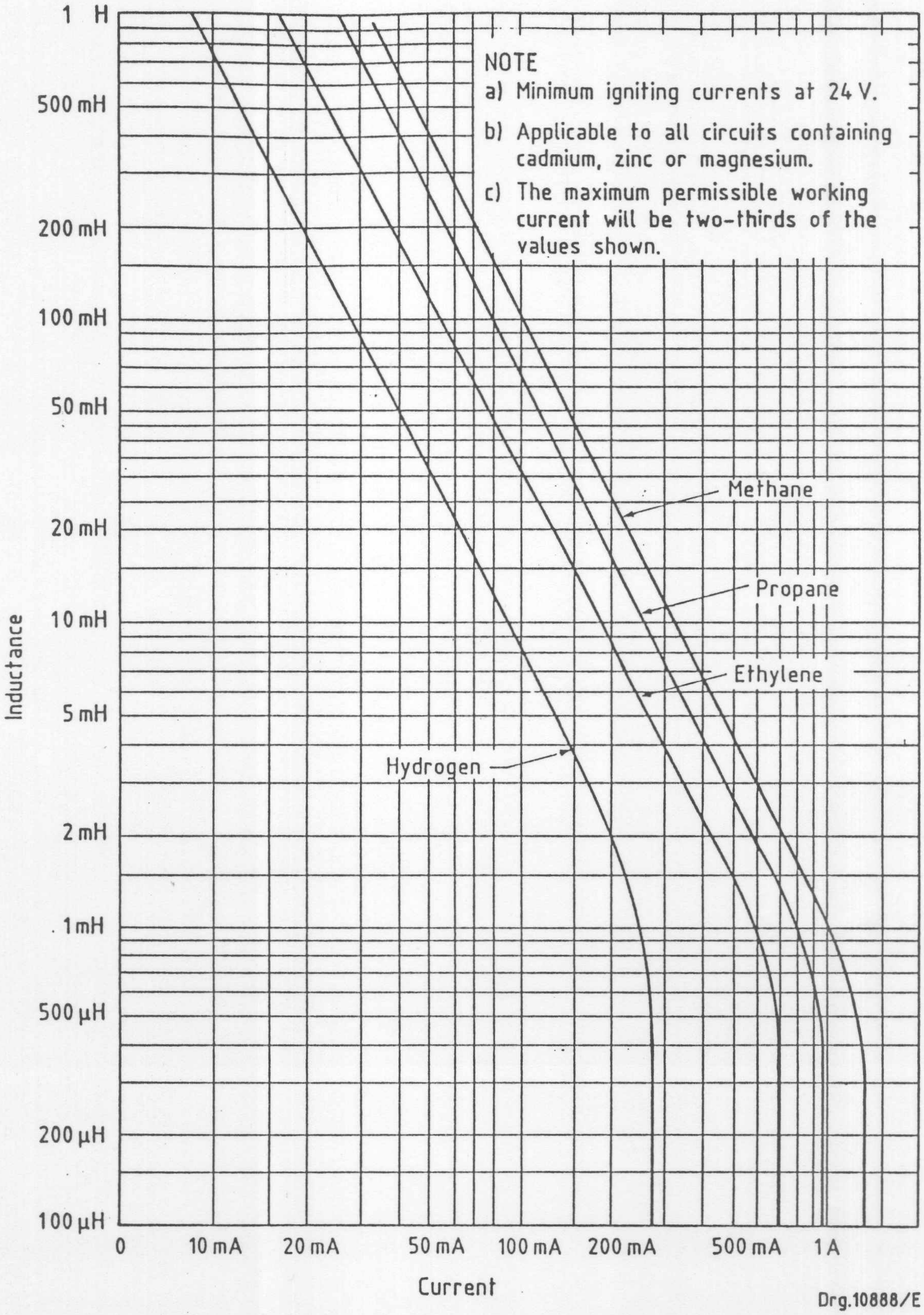

Fig. 6 - Inductive Circuits

APPENDIX A. APPLICABLE STANDARDS

(This appendix does not form part of the requirements of the specification)

Reference is made to the latest issues of the following standards:

BASEEFA 3012	Intrinsic safety
CECC 50 000	Harmonized system of quality assessment for electronic components
	Generic specifications: Discrete semi-conductor devices
IEC Publication 79-3	Spark test apparatus for intrinsically safe circuits
IEC Publication 112	Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions
SABS 150	Polyvinyl chloride (PVC)-insulated electric cables and flexible cords
SABS 1031	Type 'e' apparatus for use in explosive gas atmospheres
SABS 012	The use of light alloys in fiery mines
SABS 0108	The classification of hazardous locations and the selection of electrical apparatus for use in such locations
SABS 0157	Quality management systems
SABS Method	525

APPENDIX B. NOTES ON THE DESIGN OF INTRINSICALLY SAFE CIRCUITS[1)]

(This appendix does not form part of the requirements of the specification)

B-1 In order to design a circuit to meet the requirements for intrinsic safety, it is necessary to have information that relates voltage, current and other circuit parameters (such as inductance and capacitance) to limiting conditions for ignition as determined in the standard test apparatus. Such information exists for a number of simple circuit configurations and is set out in the curves given in Fig. 1-6.

Where information is not available for apparatus of Groups 2A and 2B, the values of minimum igniting voltage can be taken as approximately 3,2 and 1,8 (respectively) times the values for apparatus of Group 2C. It should be emphasized that this information relates to boundary conditions for ignition and, in order to design an acceptable intrinsically safe circuit, the designer has to take into account both fault conditions and factors of safety, as given in 3.1.2.

B-2 To illustrate the use of the information, consider the circuit shown in Fig. B-1 that is required for Group 2C applications.

Two separate assessments must be made, one for a short-circuit across the power supply and one for an open circuit in the complete circuit.

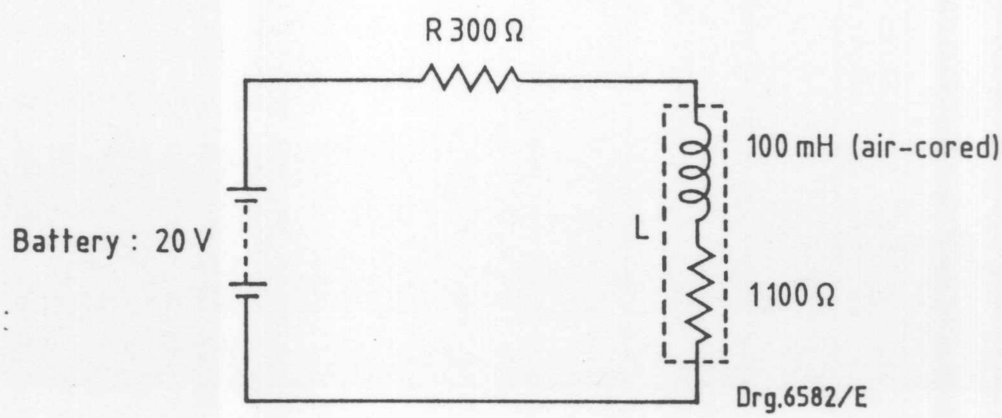

Fig. B-1 - Example of Circuit for Subgroup 2C Applications

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1)Taken from BASEEFA Standard 3012 issued by the British Department of Trade and Industry.

a) Short-circuit of power supply. The maximum battery voltage for new batteries is assumed to be 22 V . This is raised by 10 % to 24 V (see 5.7.3(b)(2)).

Reference to Fig. 2 shows that for apparatus of Group 2C (hydrogen), the minimum igniting current at 24 V is 260 mA, and the maximum permissible working current (in accordance with 3.1.2) is therefore two-thirds of that, or 173 mA . Since the actual current is only $\frac{22}{300}$ A = 73 mA, the power supply can be considered safe for Group 2C applications. A test in accordance with 5.7 would have been conducted on the following circuit:

Working current : $\frac{22}{300}$ A = 73 mA

Test current : 1,5 x 73 mA = 110 mA

Test voltage : 1,1 x 22 V = 24 V

Test resistance : $\frac{24 \text{ V}}{110 \text{ mA}} = 218\ \Omega$

In accordance with 5.7.5, the actual spark test would probably have been omitted.

b) Open circuit test. Reference to Fig. 6 shows that for a 100 mH coil, the minimum igniting current for Group 2C (hydrogen) is 28 mA . The maximum permissible working current is therefore $^2/_3$ x 28 = 18,7 mA .

The working current is $\frac{22}{1\ 400}$ = 15,7 mA and the circuit is therefore intrinsically safe for Group 2C applications.

In accordance with 5.7.5, this circuit will be tested on the spark test apparatus. An additional reason for actual spark testing is the following:

The inductance of the 100 mH coil will have been measured by means of an a.c. bridge, probably operating at some frequency around 1 000 Hz .

Depending on the core construction and core material, the distributed capacitance of the winding, and other factors, this measured inductance may or may not reflect accurately the stored electrical energy in the coil, given as $\frac{1}{2} LI^2$.

The tested circuit will be the following:

Working current = $\frac{22}{1\ 400}$ = 15,7 mA

Test current = 1,5 x 15,7 = 23,5 mA

Test resistance = 1 400 Ω

Test voltage $= \frac{23,5}{1\ 000} \times 1\ 400 = 33\ V$

If external cables are used to interconnect parts of an intrinsically safe circuit, the reactance of the cables may reduce the permissible current in the intrinsically safe circuit.

B-3 The information provided in Fig. 1-6 relates only to very simple circuits, and it may be difficult in some cases to apply such limited information to the design of practical circuits, e.g. there are considerable difficulties in defining the inductance of most iron-cored inductive components. A detailed discussion of the use of the basic information in intrinsically safe circuit design is given in SMRE Research Report No. 256 'Some aspects of the design of intrinsically safe circuits' by D W Widginton, which is available from the Department of Trade and Industry, Safety in Mines Research Establishment, Broad Lane, Sheffield, S3 7HQ, England.

APPENDIX C. QUALITY EVALUATION OF INTRINSICALLY SAFE ELECTRICAL APPARATUS PRODUCED TO THE REQUIREMENTS LAID DOWN IN THE SPECIFICATION

(This appendix does not form part of the requirements of the specification)

C-1 QUALITY VERIFICATION

C-1.1 When a purchaser requires quality verification on an ongoing basis of intrinsically safe electrical apparatus produced to this specification, it is suggested that, rather than to evaluation of the final product only, he also direct his attention to the quality management system applied by the manufacturer. In this connection it should be noted that SABS 0157 covers the provision of an integrated quality management system.

C-1.2 If the intrinsically safe electrical apparatus does not bear the standardization mark and no information about the implementation of quality control or testing during manufacture is available to help in assessing the quality of a lot, and a purchaser wishes to establish by inspection and testing of samples of the final product whether a lot (as defined in C-2.1) of the apparatus produced to this specification complies with its requirements, use the sampling plan given in C-2.

It must be noted that

a) such a sampling plan applies to fully manufactured products only; and

b) a lot that in terms of the plan is deemed to comply with the specification, could contain defective apparatus.

C-2 ASSESSMENT OF COMPLIANCE WITH THE SPECIFICATION

C-2.1 DEFINITIONS

Defective. An intrinsically safe apparatus that fails in one or more respects to comply with the relevant requirements of the specification.

Lot. Not less than 2 and not more than 300 intrinsically safe apparatuses of the same type, group, category and temperature class from one manufacturer submitted at any one time for inspection and testing.

C-2.2 SAMPLING. Use the following sampling procedure to determine whether a lot complies with the specification and deem the samples so taken to represent the lot for the respective properties:

a) Sample for inspection. From the lot draw at random the number of apparatuses shown in Column 2 of Table C-1 relative to the appropriate lot size shown in Column 1.

b) Sample for testing. From the lot or, after inspection (see 5.2), from the sample taken in accordance with (a) above, take at random one apparatus.

TABLE C-1 - SAMPLE SIZES

1	2
Lot size, apparatuses	Sample size, apparatuses
2- 8	2
9- 15	3
16- 25	5
26- 40	6
41- 65	7
66-110	8
111-180	10
181-300	15

C-2.3 CRITERIA OF COMPLIANCE. Deem the lot to comply with the relevant requirements of the specification if, after inspection and testing of the sample taken in accordance with C-2.2, no defective is found.